Validity of Telemedicine Assessment of Neurobehavioral Consequences of Traumatic Brain Injury

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Abstract
Individuals sustaining Traumatic Brain Injury (TBI) often report a constellation of physical, cognitive, and emotional/behavioral symptoms referred to as Post Concussion Syndrome (PCS). PCS can persist from months to years following injury and may even be permanent, causing disability. Due to the physical rigors of training/combat situations, military service members are at a higher risk for TBI than the general population is, and PCS is a contributing factor in many military medical retirements. The overarching goal of this project was to provide a brief web-based screen of PCS. Participants received both standard of care paper and pencil PCS instruments and web-based versions of these instruments. Fifty individuals with TBI seen at the Defense and Veterans Brain Injury Center at the Walter Reed Army Medical Center have undergone evaluation to date. Results from T-tests and correlational analyses indicate that the two versions of the instruments were highly correlated and most scores were not significantly different. Furthermore, the web-based complex attention measure (ANAM-CPT) correlated significantly with a standardized neuropsychological complex attention measure (Connors CPT-II). Therefore, the web-based screening instruments appear to be valid symptom measures of PCS.

Background

One of the paradoxes of TBI is that patients may appear normal, (i.e., be appropriate and purposeful), yet have difficulties in work-related activities and interpersonal functions, (e.g., social withdrawal, irritability, and inappropriate behavior in unstructured settings). Subtle cognitive deficits coupled with neurobehavioral changes following brain injury are often the reason that units have referred service members for care. Smaller medical facilities and clinics may not have personnel who are experienced in the unique needs of brain-injured patients. Therefore, the development of a computerized screen of PCS after TBI would be beneficial.

The feasibility of computerized testing in patients with TBI has been established in the Defense and Veterans Brain Injury Center (DVBIC) study of sports concussion at West Point (1). Consequently, a web-based telemedicine protocol was designed to provide a brief screen of PCS. Using this web-based telemedicine system, this project demonstrates the potential for remote evaluation of PCS after TBI by establishing the equivalence of web-based screening to standard of care in-person screening measures.

Table 1: Test Batteries

Standard of Care Testing Battery

Registry and Demographic Information Form
Neurobehavioral Symptom Inventory (NBI)
Post Concussion Symptom Checklist (PCSC)
Beck Depression Inventory-II (BDI-II)
State Trait Anxiety Inventory (STAI)
Connors Continuous Performance Test-II (CPT-II)

Telemedicine Testing Battery

Registry and Demographic Information Form
Neurobehavioral Symptom Inventory (NBI)
Post Concussion Symptom Checklist (PCSC)
Beck Depression Inventory-II (BDI-II)
State Trait Anxiety Inventory (STAI)
Automated Neuropsychological Assessment Metrics (ANAM)
- Stanford Sleepiness/Mood Scale II-R
- Simple Reaction Time
- Continuous Performance Test

Methods

Military healthcare beneficiaries seen for full multidisciplinary TBI evaluation at Walter Reed Army Medical Center DVBIC were eligible for participation. Eligible participants who provided informed consent received both web/computerized measures and standard of care in-person/paper and pencil versions of these measures (See Table 1).

The registry form is used to document injury characteristics such as severity; the PCSC and NBI are self-report measures used to assess common symptoms experienced following TBI; the BDI-II is a self-report scale of depressive symptoms; the ANAM is a computerized cognitive screening tool (2). ANAM and traditional neuropsychological tests used in concussion research have been shown to have similar factor structures (3). Also, the ANAM has successfully been used in the DVBIC study of sport concussion at West Point (1). The ANAM battery employed in the present study consisted of the following subtests: Stanford Sleepiness/Mood Scale II-R, Simple Reaction Time, and Continuous Performance Test. The CPT-II is a standard computerized measure of attention/concentration.

Results

Fifty participants were enrolled in the study. Most study participants were active duty males with mild to moderate severity TBI's. Complete data for all of the symptom and mood scales were available on 44 of the 50 participants, and thus were included in the analyses. Demographic and injury-related variables for the 50 subjects are presented in Tables 2 and 3.

Correlational analyses indicate that the web and paper versions of the tests were highly correlated. The correlations ranged from 0.87 to 0.95 and were all significant (see Table 4). The mean differences between the two versions of each measure were small and ranged from 0 to 2.7 points (see Table 5). Results from paired t-tests show that scores on the web and paper versions were not significantly different with one exception (see Table 5). The only significant difference found was for the State Trait Anxiety Inventory (STAI) – Trait score. While statistically significant, the mean difference of 2.7 is not clinically meaningful.

Furthermore, indices of the complex attention portion of the ANAM correlated significantly with indices of a standard neuropsychological complex attentional measure (Connor's Continuous Performance Test-II). Specifically, moderate correlations (ranging from 0.36 to 0.53) were found between the two tests for number of errors (omissions and commissions for the CPT-II), overall response speed, reaction time to correct responses, and detectability (speed vs. accuracy).

Sex	n
Male	44
Female	6

Education	n
HS/GED	37
Associates/Certificate	6
Bachelors	5
Masters	2

Handedness	n
Right	40
Left	7
Ambidextrous	3

Length of Loss of Consciousness	n
0	9
1 – 15 min	4
16 min – 1 hr	7
> 1 hr – 24 hrs	2
> 24 hrs – 7 days	9
> 7 days – 30 days	7
> 30 days	3
Unknown	9

Length of Post Traumatic Amnesia	n
0	5
1 – 15 min	10
16 min – 1 hr	5
> 1 hr – 24 hrs	8
> 24 hrs – 7 days	5
> 7 days – 30 days	2
> 30 days	5
Unknown	10

Table 4: Correlations Between Web and Paper and Pencil Versions of Symptom/Mood Measures

Measure	Correlation
BDI-II	.95
PCSC	.92
STAI- State	.87
STAI- Trait	.92
NBI- Total	.89
Note: All Correlations are significant at $p \leq .001$	

Table 5: Mean Scores for Symptom/Mood Measures for Web vs. Paper and Pencil Versions

Measure	Web	Paper	t statistic
BDI-II	14.85 ± 14.38	15.21 ± 14.13	-.47
PCSC	71.03 ± 29.03	70.06 ± 27.87	.47
STAI- State	41.45 ± 16.88	41.27 ± 16.62	.12
STAI- Trait*	43.82 ± 17.14	41.12 ± 16.29	2.28
NBI- Total	20.33 ± 17.70	20.33 ± 14.88	.00

Note: *All differences are non-significant except for STAI-Trait ($p \leq .03$)

Table 6: Significant Correlations Between ANAM Running Memory Continuous Performance Test and Connor's Continuous Performance Test-II

ANAM Indices	CPT-II Indices	Correlation
Number of Incorrect Responses	Error Score	.42*
Number of Incorrect Responses	Detectability	-.43*
Speed	Error Score	.48**
Speed	Detectability	-.36*
Mean RT for Correct Responses	Hit RT	.53**

Note: *p ≤ .05
** p ≤ .01

Conclusions:

Results suggest that a web-based screening assessment of neurobehavioral symptomatology after TBI has been successfully developed. The web versions of the symptom measures correlated highly with the paper versions of the same measures. Also, the mean scores for the two types of measures were not significantly different overall. These findings provide evidence for the validity of this web-based assessment, thus making it a useful tool for the identification of PCS.

References:

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